ON THE CONCEPT OF AN ARBITRARY REFERENCE CONFIGURATION FORMULATION FOR FINITE DEFORMATION CONTACT-IMPACT PROBLEMS[1]

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The material constitutive model and the contact formulation are two important aspects for the finite deformation dynamic contact-impact analysis. In finite deformation dynamic analysis, the hyperelastic, the hypoelastic, and the associated plastic material models are primarily used. Both the hyperelasticity and the hypoelasticity models have their own deficiencies. When the Green strain measure (or the corresponding Almansi strain measure) based on the two point field tensor is employed, the path independent hyperelastic model (for example, the St. Venant-Kirchhoff hyperelasticity) can not descriptively describe the actual strain accurately when finite deformation and finite rotation is involved. On the other hand, the controversial aspects regarding the hypoelasticity models such as the integrability, the volume decreasing effect, the shear oscillation effect, the hypoelastic effect, the stationary behavior of the the stress invariants, the satisfaction of the Clausius-Duhem inequality, and the single parameter constraint associated with the Hencky strain measure limit the applicability of the hypoelasticity models. In this regard, we propose an attempt to resolve these problems by introducing the arbitrary reference configuration (ARC) formulation and concept which can be treated as a finite deformation finite element formulation in contrast to the total Lagrangian formulation and the corresponding updated Lagrangian formulation, or it can be treated as a multi-point field tensor path dependent strain measure hyperelastic model or a piecewise linearized integrable Truesdell stress rate hypoelastic model. The focus of application is contact-impact analysis formulation. An efficient formulation for frictional contact/impact problems based on a newly developed decoupled point to segment gap vector projection model and employing the so-called arbitrary reference configuration formulation for finite elastic/inelastic deformation and the forward incremental displacement central difference time integration scheme for the equation of motion is described here. The resulting normal and tangential contact boundary formulations are easy to solve, and the contact constraints are satisfied exactly. The overall formulation is robust and efficient for the numerical simulation of finite deformation elastic/inelastic frictional contact/impact problems. Table 1 shows the numerical result of the current approach comparing with the EPIC code results, Jaumann rate results, and experimental results for Taylor impact test.

Table 1: Comparison of Taylor impact test numerical simulation with experimental results for the ARMCO iron. The temperature is 293 K and the impact velocity is 197 m/s. The initial length L_0 is 25.4 mm and the initial radius R_0 is 3.81 mm. L^* and R^* are the final length and radius of the cylinder, respectively. The number in parentheses are the percent deviation from the experimental values.

	Experiment (Johnson & Cook, 1983)	EPIC code (Zerilli & Armsrtong, 1987)	ARC	Jaumann Rate
L^*/L_0	0.802	0.816 (+1.75%)	0.813 (+1.37%)	0.813 (+1.37%)
R^*/R_0	1.59	1.66 (+4.4%)	1.627 (+2.32%)	1.627 (+2.32%)
$\bar{\Delta}$	N/A	3.08%	1.845%	1.845%
ε_p^{max}	N/A	1.6	1.7721	1.7632
CPU (ratio)	N/A	N/A	1.0	1.22

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